4. Carbon Sequestration

Background

Carbon sequestration plays an important role in the global carbon cycle. Green plants remove (sequester) carbon from the atmosphere through photosynthesis, extracting carbon dioxide from the air, separating the carbon atom from the oxygen atoms, returning oxygen to the atmosphere, and using the carbon to make biomass in the form of roots, stems, and foliage.

Every year in the United States and throughout the world a very large amount of carbon dioxide—on the order of 120 billion metric tons of carbon—is sequestered in biomass.[22] At the same time, carbon is released to the atmosphere from vegetative respiration, combustion of wood as fuel, degradation of manufactured wood products, consumption of biomass for food by animals, and the natural decay of expired vegetation. The net numerical difference, or flux, between carbon sequestration and release can be viewed as a measure of the relative contribution of biomass to the carbon cycle. World flux associated with Earth's living matter is difficult to measure, but biomass is thought to provide a net "sink" equivalent to about 5.1 billion metric tons carbon dioxide per year.[23]

Forests can play an important role in offsetting human-produced carbon emissions. On average, trees are approximately 25 percent carbon by weight (live trees are approximately 50 percent water by weight, and oven-dried wood is approximately 50 percent carbon by weight).[24] The amount of carbon a plant can sequester depends on a number of variables, including species and age, but can be quite large. For example, one large sugar maple tree is capable of removing more than 450 pounds of carbon dioxide from the atmosphere in a year. At that rate, preserving 31 trees per operating automobile in the United States would offset all U.S. automobile-related carbon dioxide emissions.[25]

Carbon sequestration on a national scale is substantial. The U.S. Environmental Protection Agency, relying heavily on the work of U.S. Forest Service Researchers Richard Birdsey and Linda Heath, estimates annual U.S. carbon sequestration (generally defined according to the guidelines of the Intergovernmental Panel on Climate Change) at 246 million metric tons carbon equivalent,[26] which offsets approximately 13 percent of annual U.S. anthropogenic emissions of greenhouse gases.[27]

Projects Reported

Fifty-one entities reported projects on Form EIA-1605 that involved forestry or natural resources that sequestered carbon or reduced emissions in 2001 (Table 14). The reporters included 45 electric utilities, 3 operating subsidiaries of an independent power producer, a real estate company, a State agency, and a city cogeneration plant engaging in a forestry habitat restoration project. A total of 369 carbon sequestration projects were reported, a decrease of 21 percent from the 2000 data year. Forestry projects were the second most commonly reported project type after electricity generation, transmission, and distribution (see Chapter 2), and they accounted for 25 percent of all the projects reported on the long form for 2001 (see Table 2 in Chapter 1). The reported forestry projects were dispersed over a wide geographic area, including 31 States and 8 foreign countries. A total of 303 domestic and 66 international forestry projects were reported. Thirty-two of the foreign projects represent individual equity shares in a single forest preservation project in Belize, the Rio Bravo Carbon Sequestration Pilot Project.

[22]Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 188.

[23]Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 39.

[24]R.A. Birdsey, *Carbon Storage and Accumulation in United States Forest Ecosystems* (Washington, DC: USDA Forest Service, 1992), p. 12.

[25]Average mileage and fuel consumption for passenger cars from Energy Information Administration, *Annual Energy Review 2001*, DOE/EIA-0384(2001) (Washington, DC, November 2002), p. 61, web site www.eia.doe.gov/emeu/aer/. Carbon dioxide emissions per mile driven and gallon of motor fuel from U.S. Department of Energy, *Sector-Specific Issues and Reporting Methodologies Supporting the General Guidelines for the Voluntary Reporting of Greenhouse Gases Under Section 1605(b) of the Energy Policy Act of 1992*, DOE/PO-0028 (Washington, DC, October 1994), Vol. 2, p. 4.19.

[26]U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000*, EPA-236-R-02-003 (Washington, DC, April 2002), p. 6-2, web site www.epa.gov.

[27]U.S. athropogenic greenhouse gases emissions were 1,883 million metric tons carbon equivalent in 2001. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002), p. ix, web site www.eia.doe.gov/oiaf/1605/1605a.html.

The total sequestration reported on Form EIA-1605 for 2001 declined by 12 percent from the previous year, to 7,956,823 metric tons carbon dioxide (Table 14). The reduction was primarily a result of the absence of a 2001 report for 164 carbon sequestration projects that were reported for 2000 under American Forests' Global ReLeaf Forests program.

Of the sequestration projects reported for 2001, most (285 or 77 percent) involved some kind of tree planting, which included afforestation, reforestation, urban forestry, and woody biomass production or agroforestry (Table 15).[28] These projects accounted for 13 percent of the sequestration (and related direct and unspecified emission reductions) reported for 2001. Although only 37 forest preservation projects were reported, they accounted for 86 percent of the sequestration reported for 2001. Ninety-one percent of the total sequestration for 2001 was reported on behalf of foreign projects, which include some very large forest preservation and agroforestry initiatives.

Nine percent of the reported projects were urban forestry projects, involving the planting of trees in urban and suburban areas. Urban forestry projects are typically much smaller than forestry projects undertaken in rural or wilderness areas. The average carbon dioxide sequestration reported per urban forestry project for 2001 was just 338 metric tons. In contrast, projects in rural or wilderness areas are sometimes large: 6 such projects sequestered more than 100,000 metric tons carbon dioxide each in 2001 (Figure 12). For the 369 projects for which data were reported, average sequestration for 2001 was 21,563 metric tons carbon dioxide per project.

Almost all (353 or 96 percent) of the reported sequestration projects were undertaken in part to fulfill commitments made under the U.S. Department of

Table 14. Number of Projects, Carbon Sequestered, and Net Reductions Reported on Form EIA-1605 for Sequestration Projects, Data Years 1994-2001

Data Year	Number of Reporters	Number of Projects	Sequestration (Metric Tons Carbon Dioxide Equivalent)	Net Emission Reductions (Metric Tons Carbon Dioxide Equivalent)	
				Direct	Indirect
1994	23	58	746,545	189	23,127
1995	44	175	1,190,754	378	48,730
1996	51	175	8,676,591	1,291	32,215
1997	56	279	9,849,807	6,160	—
1998	57	321	12,490,927	716	—
1999	53	401	9,623,599	3,406	—
2000	53	468	9,011,117	1,041	—
2001	51	369	7,956,823	1,114	—

Source: Energy Information Administration, Form EIA-1605.

Table 15. Number of Sequestration Projects Reported on Form EIA-1605 by Project Type, Data Years 1994-2001

Data Year	1994	1995	1996	1997	1998	1999	2000(R)	2001
Afforestation	26	38	38	91	101	158	181	245
Reforestation	15	81	79	91	109	136	167	10
Urban Forestry	8	17	21	23	28	28	31	33
Modified Forest Management	12	20	10	33	41	42	44	41
Woody Biomass Production and Other Agroforestry	8	14	2	3	3	3	3	3
Forest Preservation	2	22	29	38	43	38	42	37
Conservation Tillage	1	1	1	2	2	2	2	2
Other Projects	3	6	6	10	5	5	5	5
Total	**58**	**175**	**175**	**279**	**321**	**401**	**468**	**369**

(R) = revised.
Note: Project totals do not equal sum of components, because some projects are counted in more than one category.
Source: Energy Information Administration, Form EIA-1605.

[28] Afforestation is the planting of trees in unforested areas. Reforestation is the planting of trees in forest areas that have recently been harvested. Urban forestry is the planting of trees individually or in small groups in urban or suburban settings. Agroforestry is the cultivation of trees in plantations for fuel or fiber.

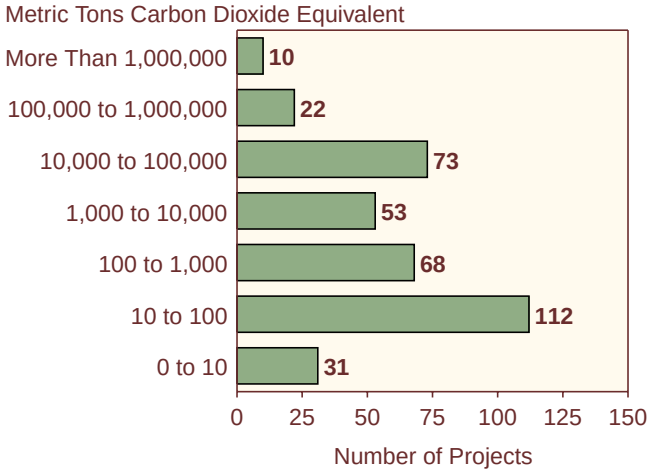
Energy's Climate Challenge program. Twenty-seven of the investors in the UtiliTree Carbon Company each submitted reports on the nine projects that were operational in 2001. All the investors reporting were also participants in Climate Challenge. In addition, 34 (9 percent) of the sequestration projects reported on Form EIA-1605 for 2001 were undertaken as part of the U.S. Initiative on Joint Implementation (USIJI). Established under the Climate Change Action Plan (CCAP),[29] the USIJI is a pilot program that seeks to encourage foreign-based emission reduction and carbon sequestration projects conducted by U.S. and non-U.S. partners. Two USIJI-approved forestry projects were reported to the Voluntary Reporting Program: the Rio Bravo Carbon Sequestration Pilot Project (Belize) and the Noel Kempf Mercado Climate Change Action Project (Bolivia).

Afforestation and Reforestation

Of the sequestration projects reported for 2001, 251 (68 percent) involved either afforestation or reforestation. The carbon sequestration and emission reductions reported for these projects totaled 637,889 metric tons carbon dioxide, representing 8 percent of the total sequestration reported for 2001. All but one of the afforestation and reforestation projects reported for 2001 were domestic.

American Electric Power, Inc. (AEP), a large investor-owned utility, accounted for the largest number of sequestration projects (14 percent of the 251 afforestation and reforestation projects) reported for 2001. AEP reported 34 afforestation projects on land owned by its operating companies, which sequestered a reported 147,271 metric tons carbon dioxide in 2001. Three of the projects were initiated in 2001. American Forests, which reported more than one-third of all the sequestration projects reported for 2000, did not report for 2001.

Figure 12. Carbon Sequestration Projects Reported on Form EIA-1605 by Amount of Carbon Sequestered, Data Year 2001



Source: Energy Information Administration, Form EIA-1605.

UtiliTree Carbon Company members reported three new afforestation projects for 2001: the Bayou Cocodrie Bottomland Hardwood Forest Restoration project, the St. Catherine-NFWF project, and the St. Catherine-ESI project. Twenty-seven separate UtiliTree members reported on each of the three projects, as well as the ongoing effects of six UtiliTree projects previously reported.

The Bayou Cocodrie Bottomland Hardwood Forest Restoration project was undertaken as a cooperative agreement between the U.S. Fish and Wildlife Service, the National Wildlife Foundation, and the UtiliTree Carbon Company. The project involves the restoration of 400 acres of bottomland hardwood on marginal agricultural farmland recently acquired by the Fish and Wildlife Service, which will be added to the Bayou Cocodrie National Wildlife Refuge. The project resulted in the reported sequestration of approximately 401 metric tons carbon dioxide among all 27 reporters for 2001.

The St. Catherine NWF and ESI projects consist of the creation of carbon sinks by converting marginal agricultural lands (600 acres in the case of St. Catherine NWF and 500 acres in the case of St. Catherine ESI) to forest cover by the planting of trees. According to the UtiliTree reporters, Federal funds would not be dedicated on the scale necessary to reforest the properties, and the land would likely be used for farming for the foreseeable future without these projects. Not only do the projects provide the benefit of sequestration of incremental carbon through the accumulation of biomass above and below ground, they will also eliminate carbon dioxide emissions from agricultural cultivation equipment. Together, these projects resulted in the reported sequestration of approximately 1,277 metric tons carbon dioxide among all 27 reporters for 2001.

Urban Forestry

A total of 33 urban forestry projects were reported for 2001 by 25 reporters, all of which were electric utilities. For the 33 projects, a total of 11,154 metric tons carbon dioxide was sequestered in 2001—an amount that would offset less than 0.1 percent of the emissions from a 1,000-megawatt coal-fired power plant.[30]

[29] President William J. Clinton and Vice President Albert Gore, Jr., *The Climate Change Action Plan* (Washington, DC, October 1993), Appendix II, web site www.gcrio.org/USCCAP/toc.html.

[30] Assuming a power plant with a heat rate of 12,000 Btu per kilowatthour operating at 85 percent availability using subbituminous coal emitting 212.7 pounds of carbon dioxide per million Btu.

Urban forestry projects are unique, in that under some circumstances they can reduce energy consumption as well as sequester carbon. Shade trees planted near buildings reduce summer air conditioning requirements; in addition, trees can act as windbreaks, reducing heating needs in the winter. Although the emission reductions associated with energy effects of urban forestry can be several times the sequestration benefits on a carbon dioxide equivalent basis, they are difficult to estimate. As a result, none of the reporting entities submitted information on energy-related emission reductions for urban forestry projects.

Forest Preservation

Forest preservation projects sequester carbon by avoiding the harvesting of timber or clearing of land and thus preventing the release of stored carbon. A total of 37 forest preservation projects were reported for 2001 by 29 reporters. The two largest forest preservation projects were reported by AES Hawaii and AES Shady Point, subsidiaries of the AES Corporation. Together, these two projects sequestered a reported 5.68 million metric tons carbon dioxide in 2001, representing 83 percent of the total sequestration reported for forest preservation projects.

Two utilities (AEP and PacifiCorp) reported on the Noel Kempf Mercado Climate Action Project in Bolivia, which was accepted by the USIJI in November 1996. The project, which involves the preservation of 634,286 hectares of land on the southern and western boundary of the Noel Kempf Mercado National Park by incorporating it into the park, includes the following components: (1) carbon dioxide emission reductions through the cessation of logging activities and the protection of forest land from conversion to agricultural use; (2) protection, regeneration, and preservation; and (3) leakage prevention.[31] The sequestration reported by AEP and PacifiCorp totaled 803,484 metric tons carbon dioxide for 2001.

The Rio Bravo Carbon Sequestration Pilot Project, a forest preservation project in Belize, was included in the reports submitted by 27 utilities, each of which reported its prorated share of the total sequestration for the project. Begun in 1995, the project is being undertaken through a partnership between Cinergy Corporation, DTE/Detroit Edison, PacifiCorp, Wisconsin Electric Power Co., the UtiliTree Carbon Company, the Nature Conservancy, and a Belizean nongovernmental organization (Programme for Belize). The project includes the purchase of a 14,400-acre parcel of endangered forest threatened with conversion to agriculture.

The entire Rio Bravo Carbon Sequestration Pilot Project sequestered an estimated 147,759 metric tons carbon dioxide in 2001, of which 142,946 metric tons (97 percent) was reported to the Voluntary Reporting of Greenhouse Gases Program.[32] This represents an 77-percent decline from the sequestration reported for 2000 (620,991 metric tons carbon dioxide), which occurred because the preservation of the forest is nearing completion. The reported carbon sequestration for this project was estimated by defining a reference case that assumes a profile of carbon releases that would have occurred if the project had not been undertaken and the forest had been converted to agriculture. The estimated carbon sequestration equals the projected avoided carbon releases. Project completion will occur when the conversion to agriculture would have been completed under the reference case scenario.

Only one domestic forest preservation project was reported for 2001, by Alliant Energy, which reported sequestering 1,597 metric tons carbon dioxide by maintaining forested buffer lands around its power plants.

Modified Forest Management

Of the 41 modified forest management projects reported for 2001, 28 were associated with two related reduced-impact logging initiatives in Malaysia. The first initiative was a pilot project reported by PG&E Corporation.[33] Started in 1992, this project implemented new logging techniques with the goal of reducing logging damage by 50 percent. The new techniques include pre-cutting of vines, directional felling, and planned extraction of timber on impact-reducing skid trails. Twenty-seven utilities reported their shares in the second initiative—a full-scale project sponsored by the UtiliTree Carbon Company that introduced reduced-impact logging practices to 2,422 acres of forest beginning in 1997. The second initiative increased sequestration by a reported 14,767 metric tons carbon dioxide equivalent in 2001.

[31]Leakage refers to the migration of logging and land-clearing activities that would have occurred in the preserve to areas outside the preserve, which would offset the sequestration achievements of the project.

[32]Twelve UtiliTree participants did not submit reports to the Voluntary Reporting Program for data year 2001, including one Canadian utility that is ineligible to report.

[33]This project was originally sponsored by New England Power Company and reported by its parent company, New England Electric System (NEES) Company. In August 1998, USGen New England, Inc. (USGenNE) completed the acquisition of New England Electric System (NEES) Company's hydroelectric and fossil power generation business previously operated by New England Power. As part of the acquisition, the rights to the emission reductions and carbon sequestration achieved by this and other projects were transferred to USGenNE. For 2000, the activities previously reported by USGenNE were incorporated into the report submitted by its parent, PG&E Corporation.

DTE Energy/Detroit Edison conducted selective harvesting operations in previously unmanaged wood lots and reported increasing sequestration by 1,398 metric tons in 2001. Alliant Energy reported enhanced forest management activities as a component of its afforestation project. AEP reported 11 projects that involved the utility's annual additions to its modified forest management efforts conducted in upland central hardwood stands. The stands are selectively harvested, removing over mature, mature, cull, and diseased trees, and other steps are undertaken as necessary to improve growing space relationships and maximize the growth rates of the stands. The combined additional sequestration reported by AEP for these projects in 2001 was 15,735 metric tons carbon dioxide.

Forest Plantations

Forest plantations include woody biomass production and agroforestry. Woody biomass production is the cultivation of trees in intensively managed plantations for the purpose of producing fuel or fiber. Agroforestry involves mixing trees with annual crops to provide wind shelter, stabilize soil, and produce fuel wood and fruit crops.

One of the three woody biomass production projects reported for 2001 was a project involving the establishment of a short-rotation cottonwood plantation on a river bottom site in Alabama, reported by J.M. Gilmer and Company. The cottonwoods will be harvested on a 12-year rotation and used as biofuel (displacing fossil fuel) or for pulpwood. After cutting, the cottonwood stand will be regrown, and a second 12-year crop rotation will begin. J.M. Gilmer and Company reported that this plantation sequestered 100 metric tons carbon dioxide in 2001.

AES Thames reported an agroforestry project in Guatemala that involves establishing a plantation of fruit, pulp, and fuel wood trees. Using a revised estimation method, AES Thames reported that its project sequestered 410,000 metric tons carbon dioxide in 2001.

The third forest plantation project reported for 2001 was Minnesota Power's Short Rotation Woody Crop Establishment project, in which the utility contracts with landowners enrolled in its Conservation Reserve Program to plant hybrid poplars. Minnesota Power reported the sequestration of 15,593 metric tons carbon dioxide through this effort in 2001.

Conservation Tillage and Other Sequestration Projects

Not all the carbon sequestration projects reported for 2001 involved conventional forestry. Other projects reported involved conservation tillage, reuse of utility poles, and restoration of terrestrial, wetland, and marine habitats. Seven such projects were reported for 2001, including one new project reported by the Indiana Association of Soil and Water Conservation Districts that involves the collection of county-level data on historical agricultural and drainage practices by the 92 Soil and Water Conservation Districts in the State. Although sequestration data for 2001 was not available, the association indicated that the sequestration data reported for previous years represent long-term changes in agricultural practices in the State of Indiana.

Exelon (formerly Commonwealth Edison and PECO) reported on its Illinois Prairie Grass Plantings project, in which native prairie grasses are planted on various properties in the utility's State system. In contrast to conventional turf grass, the deep root systems of native Illinois prairie grasses afford environmental benefits that include reducing soil erosion and downstream flooding and eliminating the need for irrigation, fertilizers, pesticides, and herbicides. In addition, the deeper root systems sequester more carbon dioxide. The project claimed responsibility for the sequestration of 658 metric tons carbon dioxide in 2001. In another project, Exelon reused wood utility poles that are structurally sound in order to avoid the harvesting of trees to manufacture new utility poles. The utility pole reuse project was reported to have sequestered 753 metric tons carbon dioxide in 2001.

Alliant Energy reported on a conservation tillage project that involved the conversion of 696 acres of former corn and soybean row cropland to a variety of other uses, including tall grass prairie, wetlands, conservation tillage, and oak savanna. This project reportedly sequestered 4,390 metric tons carbon dioxide in 2001. Alliant Energy also reported on a habitat restoration project for 2001.

Other carbon sequestration projects include the reclamation of 6 acres of wetlands by Conectiv Atlantic Generation and reclamation of wetlands in Texas and Louisiana by Entergy Services, Inc. The two projects sequestered a reported total of 54,893 metric tons carbon dioxide in 2001.